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Teaching and Learning Immersion and Presence

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Abstract

It is known since Socrates that people learn better by experiencing a problem by themselves and by finding a (the) solution(s) by their own. It is however not always possible to offer such freedom to students when teaching the concepts of immersion and presence in virtual environments due to the technological complexity and the intrinsically subjective nature of these concepts. This paper describes a pedagogical experiment involving a standard videoconferencing system and presents easily reproducible exercises intended to let students experiment with an immersion system, experience the feeling of tele-presence, and observe the inherent problems linked to communication, field of view, or latency issues. The test performed shows that such experimentation has positive pedagogical impacts, both from the learning and students motivation perspectives.

Keywords--- **Teaching, learning, immersion, presence, tele-presence.**

1. Introduction

The development of a virtual reality (VR) system is known for being a multi-disciplinary task; computer graphics with all its sub-fields (image processing, 3D rendering, 3D optimization, GPU computing, etc.), electronics and tracking devices, software and interaction design, character animation and artificial intelligence, sound processing and acoustic, and so on. An exhaustive list could not be established without considering a specific application case, but the point is that VR systems are developed in teams of experts from the engineering and the application sides, hardly by a single person.

So, which competences and knowledge shall all these VR experts have in common? What makes the core of a VR system? The consensus is that what makes a “virtual reality” system is its ability to immerse physically a user in such a way that he or she eventually feels like 'being there' in the virtual environment [1], neglecting for a while that his/her mind is in another location that the body [2], and forgetting about the technological mediation of perceptions [3]. This is what is synthesized in the concepts of immersion and presence, and why we consider that the teaching of these concepts has to be integrated to any VR curriculum as a topic on its own.

The teaching of presence cannot be dissociated from the polemic on its definition, nor from the technological background in which it is raised. The difficulty to grasp the concept as well as the subjectiveness of the feeling makes it a hard topic to teach in an engineering context. However, neglecting the presence factor while engineering a VR system often leads to the design of, at most, an advanced 3D GUI (and at worst an useless torture). Conversely, for people on the design and application side, the complexity of the field leads to misinterpretations of the goals and possibilities offered by VR technology. Fallacious associations such as “because it uses a head-mounted display, it provokes presence” are common, although they are neglecting the underlying principles of VR. It is therefore necessary to include every aspects of immersion as a prerequisite for presence, and also to deal with the issues such as usability, latency and communication.

We can see during teaching the concepts of immersion and presence that the complexity comes from the intimate implications between technological and human factors. It is hard to maintain a good balance between both, and because students also have their preferences, the prioritization (or rather the blending) of the topics raises pedagogical problems too. On a more pragmatic level, the equipment for VR is not easily affordable and rarely dedicated to teaching. The available resources should therefore be optimized to provide students with the maximum experience during their limited access to it.

In this context, and with the ambition to provide students with a clear understanding of the concepts through experiment, we designed a short workshop where no technology development is required and little lecturing is done. In order to stick to the core of the problem, we decided to go back to the original principle of tele-presence at a distant location. The hypothesis is that, having a videoconferencing system and minimal VR equipment, students should (re)discover by themselves the problems for achieving immersion and tele-presence. After an experiment in such context and based on the resulting deep understanding of the core concepts, teachers should be easily able to generalize and include the other aspects of VR, such as 3D graphics, tracking, or HCI.

In this paper, section two presents a short overview of the education in virtual reality and, more specifically, investigates how immersion and presence are usually taught, including the pedagogical challenges for doing so. Section three describes our pedagogical experiment and explains how using videoconferencing as a basis for experiencing immersion and presence can be appropriate. Sections four relates how the experiment was conducted, and section five contains the results we obtained. Eventually, the conclusion synthesizes the results and discusses the interest for performing such workshop when teaching VR.

2. Teaching virtual reality and presence

Although it is not possible to make an exhaustive overview of VR teaching material and VR educations, this section aims at giving a sufficiently good picture of the field and of problems met when teaching immersion and presence.

2.1. Educating VR professionals

In the ACM-IEEE Computing Curricula on Computer Science from 2001[1] [4], the course 'Virtual Reality' is proposed under the topic 'Graphics and Visual Computing (GV)'. Although these are just guidelines, this course represents quite well the typical contents of a university course on VR: stereoscopic display, haptic devices, viewer tracking, time-critical rendering, applications in medicine, simulation and training, etc. The extensive survey of VR courses taught at universities worldwide made by Burdea in 2003 [6] confirms this tendency, where real-time 3D simulation is at the core or VR teaching. However, immersion and interaction is not always equally emphasized and several courses labeled *virtual reality systems* or *virtual worlds* are in fact almost exclusively on computer graphics.

A relatively large collection of books is available on Virtual Reality, but few can be considered as textbooks and are sufficiently recent to be appropriate today. In addition, as the computer graphics and software issues evolved very quickly in the last decades, only the books covering extensively the immersion technologies and the applications could benefit from a long term interest [6] [7] [8] [9] [10].

The teaching of VR in itself was rarely considered as a research matter, not that it was not addressed properly, but certainly because of the usual distinction made between the research and the teaching topics. Still, Bell [11], Stanfield [12] or Burdea [6] did consider the matter of sufficient importance to communicate their proposals for a VR curriculum or to share their opinions on the topic.

2.2. Concepts of immersion and presence

The education of VR professionals is usually a computer science matter, handled as such by technical universities. It is therefore not surprising that topics like “Human factors in VR” [7], “User interface issues” [9],or “Social & Psychological Issues” [10] are the only places where one could expect to discuss the notions of immersion or presence However, these topics rather focused on engineering factors like user performance, health and safety, or societal implications of VR, as they ought to be part of a serious design. Teaching may also focus on the perception disturbances caused by immersion, such as “Equilibrium and simulator sickness” [12], or “cybersickness and sensorial substitution” [9] in few cases. However, as Burdea points out, “Virtual reality is not just a medium or a high-end user interface, it also has applications that involve solutions to real problems”[6]. This may be why teaching VR as pure computer science may not be the only way to approach the field.

In fact, the problem of presence is often addressed through immersion, which in itself is a better defined engineering problem. To be more specific, Sherman [7] defines *physical immersion* as the “synthetic stimulus of the body's senses via the use of technology”, in opposition (or in complement) to *mental immersion* that he considers as a synonym for sense of presence. Even then, maybe in regard to the potential lack of interest of his audience or to its limited background in the field, he addresses the topic with care, “Without getting into that philosophical discussion...”[7, p10]. To obtain more detailed discussion on the topic, it is either necessary to refer to specialized literature (e.g. [13]), or to investigate in depth the extensive set of publications discussing the problem (e.g. [14] [15]). However, the first option requires background in psychology or communication theory to allow a clear understanding and the latter relies on the knowledge of several former works, often leading to the need to retrace the references and the former researches, a competence which is only embryonic with students at a Master level (not even considering it for BSc).

However, it is necessary to deal with these topics early enough in the education because they are the core of any VR application. To take an example classified by Reyes-Lecuona et al. [16] as an "Applications requiring presence", the psychotherapeutic use of VR to treat phobias relies almost exclusively on the hope that the impact of the simulation will be as strong as if the person had actually experienced the scene in vivo. In this emerging field, the need for a common expertise between technology and application experts cannot be ignored.

The distinctions between what could be simplified as the engineering versus the humanistic approaches may, hopefully, only be at a semantic level. It is clear that VR professionals are aware of the debates going on at a scientific level on the definition, the comprehension and the evaluation of the sense of presence. What is less clear is the way to address the topic when teaching it. This difficulty may even be one of the causes of the problems of its teaching and, by extension, of the disagreements and debates on presence. This supports, in our opinion, the need to teach immersion and presence as a core and common element in the education of both the future experts and the users of VR, and requires us to find a way to do this in a manner approachable by non-engineers as well.

2.3. Pedagogical issues

From our experience when teaching virtual reality, lectures on the topic of presence and demonstrations with our research equipment were both a positive step towards the understanding of the concept.

[1]The *2001 Computer Science Curriculum* is the first of the *Computing Curricula Series*, but is still today officially part of the updated *Overview volume on Computing* from Sept. 2005. http://www.acm.org/education/curric_vols/CC2005-March06Final.pdf

However, lecturing does not let students experience the feeling itself and has a limited impact on students as they consider presence as 'yet another abstract concept'. To the opposite, a 'demo' approach lets them experience the feeling, but with the demonstrations being (hopefully) technologically advanced, students are left with the impression that this is out of the reach for them, confusing the concept with the technological complexity. A combination of the two approaches is definitely positive, but there is always the chicken-and-egg issue regarding what to teach first. When starting with the theory, teachers think that it will be brought into practice at a later development phase, but the learning reality is that, having no experience to relate the theory to, students may misunderstand it or simply ignore it as irrelevant. On the other hand, leaving the presence issue to be dealt at a later stage (once students have seen the context and the technology of immersion) may seem better, but students then tend to consider it as presented to them: a bonus, an optional point to discuss eventually once a system is made.

Another pedagogical problem while teaching such abstract topic is the need to take the profile and expectations of the students into consideration. We have to deal with two complementary profiles involved in the field of VR: the engineers and the potential users. With the first group, the two reactions mentioned earlier often occur. With non-technical students (either design-oriented or interested in the field for how it could be used), the problem of presence is often of great interest, much preferred compared to the technological aspects of immersion, programming, or computer graphics. The risk here is that by preferring a discussion on presence at the expense of dealing with the technical aspects, the students will lack the understanding of the technology and only reinforce their original perception of VR as being 'black magic'.

We believe that both aspects should be dealt with equal importance, in parallel and linked together if we want to provide our students with all the elements required for designing and developing successful VR systems.

3. A pedagogical experiment with video-conferencing

This section explains our motivations for teaching immersion and presence by a simulation of a tele-operation and tele-presence system, and presents how we imagined that the videoconferencing technology could be used. The hypothesis made at this stage will be evaluated in the results section.

3.1 Pedagogical objectives

Our objective is to teach the concepts of immersion and presence without relying on students' programming skills or knowledge in computer graphics. The reason for this is that although these competences are required for being VR engineers, they are not strictly necessary to understand the fundamental concepts. This focus also enables us to teach the basic concept to wider audience, not only to engineers. In

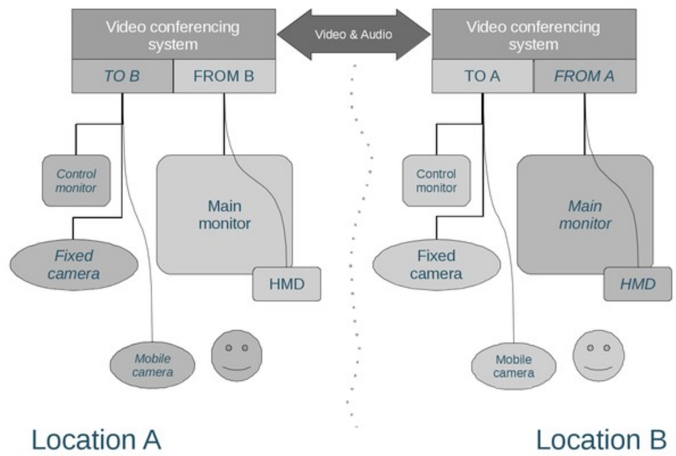

Figure 1. Setup of the teleconferencing system.

addition, we consider appropriate to refer back to the origins of the phenomenon of tele-presence – visiting a remote location through mediated feedback.

The elaboration of this experiment took place in the specific context of the project oriented problem based learning methodology [17] used at our university, but we assume that the problems we have are certainly similar in other places. Our students are required to make a project within the "Virtual worlds" theme to validate their second semester of the Master in “Medialogy”[2]. They need to know what VR is and what makes a successful VR experience before having built any. We want to give them sufficient material to allow them to make judicious decisions during the early analysis and design phases of their project. Immersion and sense of presence being at the core of their project, they have to fully understand these concepts before mastering the technology itself (which they learn later on during the development phase).

We propose an activity to teach these concepts and, maybe more importantly, the difference between them. We prefer a 'learning by doing' approach which can support deep learning. We mean deep learning as defined by Biggs in [18], i.e. enabling the students to deepen their understanding from practice to understanding causality and generalization to new problems. Here is in more into details the aspects we want to address:

- **Use of a tele-operation system**; communication issues, camera viewing possibilities (objective or subjective) and limitations (field of view).
- **Use of an immersive setup**; mediation of perception (HMD), latency problems, change of reference frames (local and distant places).
- **Potential emergence of presence**; experience the feeling of presence, or what would be the conditions for experiencing it (embodiment, affordance).

[2] See study guidelines of AAU at http://esn.aau.dk

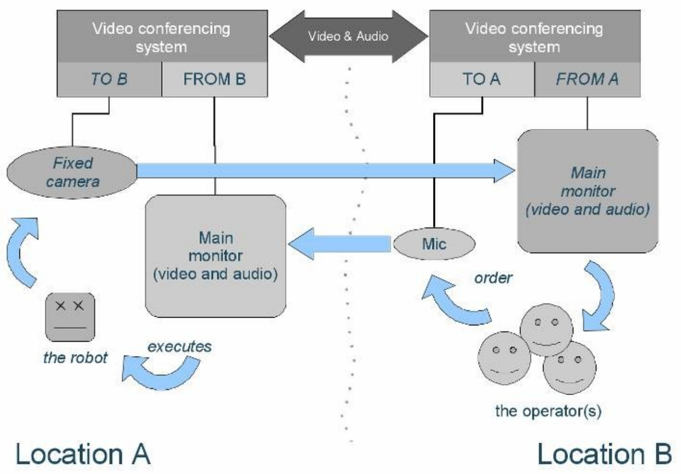

Figure 2. Action-reaction loop in exercise 1.

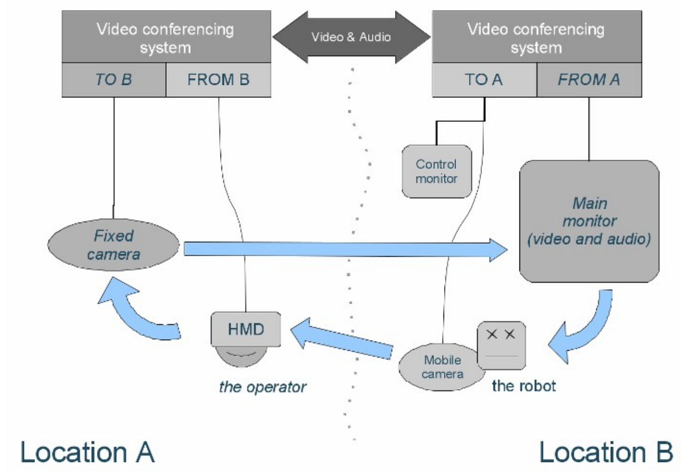

Figure 3. Action-reaction loop in exercises 2 and 3.

For each of these aspects, students shall use the technology and discover its inherent problems and limitations. They should be able to make a clear distinction between the potential of the tele-presence technology used (visiting a remote location "as if you were there") and the reality of the immersion setup (what can really be achieved).

3.2. Setup

The setup needed for this experiment is presented in figure 1. It requires a decent video conferencing system, a mobile camera and an HMD on each side. What is important is that people from one location can always hear people from the other end (full duplex connection) and can see the image sent to them either from a fixed camera (the one integrated in the videoconferencing system) or a mobile one. The incoming video signal shall either be displayed on a monitor (the default one of the videoconferencing system) or in an HMD. It is also good if there is a monitor to review the local image sent to the other end.

3.3 First exercise: tele-operation of a 'robot'

The first exercise consists of simulating the control of a distant robot. A student from location A is blindfolded and placed in the room to play the 'robot'. The operators at the remote location B should control the 'robot' by giving verbal orders. Figure 2 shows how the action-reaction loop works for controlling the robot. The task of the operators is to have the robot find an object on the ground and place it in a basket elsewhere.

The exercise 1 has two phases:

- **First phase: objective point of view.** The camera has a fixed position and sees the whole room (our system also provided us with a remote motorized control of the camera, but this is not necessary).
- **Second phase: subjective point of view.** The 'robot' holds the camera on the shoulder and moves with it.

Pictures showing these phases performed during our experimentation can be found in figure 4. Several outcomes can be expected from these experiments. First, students should encounter communication problems when controlling the robot. Typically, on the operators side, they have to work together to give a coherent message and minimize noise. Moreover, it is hard to control the robot accurately; the orders need to be specific and clear. Secondly, the visual feedback on the robot action greatly influences the ability of operators to orient themselves (i.e. potential confusion for left/right indications in the objective view), or to locate the robot and judge distances (e.g. due to the limited field of view in the subjective viewpoint). Finally, on the less serious but still important side, the confusion and mistakes made on each side should lead to funny situations and to a playful experience for the students.

At the end of the two sessions and after each side has performed both phases, the teacher shall open the discussion on the experience. This could take the form of a comparative study to determine the more efficient viewpoint to control a robot at distance; a camera over the whole scene or a camera mounted on the robot? Students should make a list of pros/cons for each possibility and identify the main problems (communication, field of view, localization).

The transition to the next exercise is made by the teacher by emphasizing the possibility to be immersed in the remote location if one can see what the robot sees.

3.4 Second exercise: immersion with HMD.

In the second exercise, a student from location A wears head mounted displays (HMD) and explores freely the remote environment B through a 'robot' equipped with a camera. In order to move the camera according to the operator's movements, the 'robot' holds the camera while looking at the operator on the main monitor, trying to follow as well as he/she can the movements of the person's head. Figure 3 shows how the action-reaction loop works for following the operator's movements. The goal for the operator is to navigate in the remote location, to find an object, and to place it in a basket.

Figure 4. Students playing the 'robot' in exercise 1; the operators have an objective or a subjective view.

The exercise 2 has two phases:

- **First phase: proof of concept.** Can the operator achieve its task? How does the 'robot' follow the operator navigation and what are the difficulties / problems?
- **Second phase: improved version.** How to improve the system? Considering the technology used cannot be changed now, find conceptual or practical solutions which could help the 'robot' and/or the operator.

It is expected that it will be very difficult to follow the operator's movements; he/she has to move very slowly to allow the robot to mimic his/her gestures. Inconsistencies between the movements and the visuals feedback may cause: misunderstandings, frustration or even cybersickness. In addition, when trying to follow the operator's movement, the robot will certainly loose track and may very well end up in a very different place than the operator. Students should notice this and relate to potentially similar problems with VR devices (e.g. drifting of accelerometer-based sensors).

For the second phase, students should propose solutions to help in the orientation and localization in the environment. Here the teacher may guide them and suggest/support the idea of building a similar reference system on each side. Having prepared a set of letters and numbers on paper, the students can be prompted to use them as a way to build a common reference system. Once they come up with a solution (agreed after discussion on both sides), they shall implement it (e.g. make a grid on the floor on each side) and perform the test again in the new conditions. Our hypothesis is that this second trial will be better from the localization point of view.

Still, it is expected that the robot should manage sufficiently well to mimic the operator's movements and permit accomplishing the task (left picture in figure 5 shows the operator 'picking up' the object at distance). The exercise ends with a brief discussion of the problems encountered and the evaluation of the improvement proposed.

Figure 5. Students tele-operating in exercises 2 and 3.

3.5 Third exercise: Can we achieve presence?

This exercise follows the same principles as the second one (HMD, reference system allowed but not necessary) but tries to go further in the use of the setup to achieve a sense of presence in the remote location.

The exercise 3 has two phases:

- **First phase: embodiment.** The distant robot now has obstacles to avoid (chairs); how does this influence the task of the operator? The operator still has to find the object and place it in the basket.
- **Second phase: the avatar.** The distant robot is the avatar of the operator in the distant place, and acts as himself in a social situation. Here, the operator should approach every person at the remote end, ask for their name (they could give a false name to confuse him a bit), and then return to say goodbye using the given names.

It is expected that during the first phase the operator avoids the chairs, although he knows there is none in front of him; he uses his perceptions to allow the distant 'robot' to find its way around the chairs (the picture on the right in figure 5 shows the operator facing the remote chair). The teacher shall take the opportunity to discuss this with the students and introduce the concept of embodiment. To go further, he can also relate the actions of the operator (avoid the chairs) with the mechanisms of affordance, i.e. the perceivable possibilities for action [19].

In the second phase, the different nature of the task and its social aspect (focus on people's names) should help in having a stronger feeling of presence. References to the operator's real location (e.g. seeing yourself on the monitors) may however break the flow (teacher could then refer to the term 'break in presence' – BIP).

3.6. Workshop protocol

These exercises should be grouped in the form of a pedagogic workshop on the theme 'Tele-operation and presence'. Here is the protocol we prepared, considering a total duration of four hours (220 minutes total + 20 minutes break);

1. Welcome, tests and presentation of the system (10 min).
2. Introduction to the workshop (objectives and theory) (10m).
3. Exercise 1; phase 1 (20m), phase 2 (20m), discussion (20m).
4. Exercise 2; phase 1 (20m), phase 2 (20m), discussion (20m).
5. Exercise 3; phase 1 (20m), phase 2 (20m), discussion (20m).
6. Closing discussion (20 min).

The closing discussion shall require the students to reflect on the experiment they did and to synthesize the most important aspects.

4. Experimentation

In this section, we describe our experimental conditions and present how this pedagogical experiment was conducted.

4.1. Context

The workshop 'Tele-operation and presence' was integrated in the curriculum of the Media technology Master in the course 'Virtual Reality Design' that targets the learning of VR technologies and the practice with specialized equipment and software. It took place in the middle of the course, after student have been introduced to the field, but did not rely on the software aspects covered elsewhere in this course (typically 3D graphics). The profile of these students is a mix between a multimedia designer and a computer scientist, allowing them to be able to deal with technology in a technical team while focusing on the human and design aspects of products using new media.

Two additional teachers were asked to be observers, one on each side, but their presence was required only for the scientific purpose of this experiment, not for the teaching itself.

4.2. Setup

The video conferencing system we used is a Polycom HDX 9004™ running with 4 video streams. It auto-selects the codec depending on line and input quality. This system provided us with high quality image and sound with a relatively low latency. It is also equipped with a Smartboard allowing us to make slide presentations and drawings on screen that get transmitted to the other end. For the mobile camera, we used standard DV camcorders (e.g. Sony DSR PD150) to feed a composite signal in the video-conferencing system.

The HMD used was an eMagin 3D Visor Z800 running at 800x600 resolution. It was plugged to the videoconferencing system through VGA connectors. However, we only had the HMD on one side and could perform the exercises 2 and 3 only in one direction.

Table 1. Student synthesis after the workshop.

Synthesis of problems encountered
Field of view too narrow (mobile camera) Delay/synchronization problems Communication issues; sound quality and noise, Understanding of commands (language) Relative reference; mapping of movements, common reference system Other technological limitations (HMD quality, image resolution, etc.) Evaluation of presence (how to quantify?)
Synthesis of what worked
We see each other! Achieved a bit of presence, or even quite a lot (subjective) All tasks were accomplished People adapt, learn how to use the system (e.g. operator)

4.3. Observations on the course of the workshop

The workshop was scheduled for four hours, but actually lasted just a bit more than three; the protocol (section 3.4) was followed, but each exercise simply did not require as much time as planned. Four students and the leading teacher were at one end, and six students were at the other end (supported by a local teacher).

The leading teacher used slides as a visual material to support his explanations of the exercises, showing for examples the diagrams of figures 1 to 3. He drove the experiment by following the protocol and moderating short discussions after each exercise. Every exercise went fine, without any technical breakdowns or anything that could have significantly disturbed the experiment. The sound quality was not fully satisfactory at the beginning due to the location of the microphone and to the acoustic feedback; after adjustments, the conditions were sufficiently good to communicate without problems. Pictures of students performing the various roles (operator or robot) during the workshop can be found in figures 4 and 5. The discussions took place in the form of open debates, supported by the Smartboard used as a shared writing support for each side.

After the workshop the students were asked to write anonymously on a post-it note what they liked and what they disliked during the workshop. Following this, they had an open post-session discussion with the observing teachers. The goal here was to get students immediate reaction on the way the workshop was conducted.

5. Results and evaluation of pedagogical objectives

This section synthesizes the students' feedback and the observations and comments from the observing teachers involved in the workshop.

5.1. Students' synthesis and feedback

The closing discussion was quite productive and lead to the construction of a table synthesizing quite well the encountered problems and the aspects which succeeded. Students listed them as shown in table 1.

Regarding students feedback, they were unanimously happy with the experiment, but for different reasons. They found it “fun” overall, but more interestingly, they related to the subjective experience they had when having a particular role in the exercise: “What I liked: embodiment as a robot”, “Loved the robot operator experiment as it allowed for a short moment of presence”. On the other side, “mostly technical problems” were conveyed as what they disliked the most.

5.1. Exercises hypothesis validation

First of all, and as expected for exercise 1 (but also true for all of them), we observed a very good involvement of the students during the experimental phases, both for the student directly performing the activity and for the others supporting him or her. As a positive influence of this, students were also active in the discussion and reflection phases which followed.

In addition of being able to identify the limiting factors for controlling the robot (table 1), students naturally tried to use a 'standardized' way to give orders (“Robot, turn right”, “Robot, walk two steps forward”) and experimented with various levels of precision for specifying the amount of movement.

In the exercise 2, the possibility to follow the operator’s movement was verified with various levels of success. The main factor was the ability of the 'robot' to follow the gestures (some students being quite good at it whereas others could not manage meaningfully) and not the use of a reference system. In fact, in the second phase, the reference system may even have confused the students.

The first phase of exercise 3 went as expected, and was perceived as a continuation of exercise 2. The second phase was not as convincing as expected and the students reported a lower sense of presence in this situation than before. However, the social aspect of it seemed to have been appreciated as students improvised by themselves the reverse situation which was not planned; as the location B did not have an HMD, they could not do the same, but the students did it in a way by controlling the robot with voice, thus finishing the session with a goodbye to everybody.

5.1. Immersion vs. presence

Several levels of immersion were used in the experiments, ranging from a regular, non-immersive setup using a non-moving camera and a TV screen displaying the signal from the remote end, the same but with a mobile camera attached to the 'robot', and finally a mobile camera combined with a head-mounted display with peripheral vision partially occluded.

The different immersion levels had an impact on the feeling of presence, with the head-mounted display being both most immersive and most presence-inducing according to the feedback from the students; “I felt as if I had the sponge right in front of me and tried to grab it”.

On the other hand, the more immersive the experiment became, the more pronounced were the aspects interfering with presence; latency (both network-induced and camera operator induced), poor synchronization between the motion of the 'robot' and the remote operator (exasperated comment from a student: “He didn't follow what I was doing at all!”), lacking registration/common reference frame and quality of the sound being transmitted.

The students managed to correctly identify all the major issues and proposed remedies, such as introduction of tracking, the need for low latency connection. The need for common reference frame was not identified clearly, however the students made comments and observations on the difficulty of judging the relative positions of objects and distances toward obstacles. The students were led towards one method of establishing a common reference frame by using the alphanumeric markers on the floor, but the students discovered it wasn't very effective.

On the other hand, the students discovered few tricks on their own that weren't anticipated in advance. One such idea was the usefulness of having an object of a known size in the field of view of the camera of the 'robot' for judging distance to the objective –typically an outstretched hand. The remote operators demanded the hand to be visible all the time and commented that this helped them a lot to see how far they are from the sponge.

Another trick one of the students used to judge the distance to an obstacle (row of chairs) was to let the 'robot' run into the chairs. When asked about this, the student explained that once he knew the robot is touching the chairs, he could estimate his position in the space better, relating it to the mental image of the room he remembered from seeing before.

5.2. Pedagogic issues

The students have managed to fulfill the objectives of the seminar that is to learn what is immersion, what is sense of presence and what are the factors impacting both of these. The students from both campuses liked the seminar very much, even commented that it was “the best lecture they ever had”.

The post-session discussion has also indicated that the students have achieved deep learning, managed to understand the concepts taught and put them in context with other issues (such as the importance of tracking, latency, etc.). Using Biggs's SOLO taxonomy [18], the students achieved at least the relational level, being capable to find causal links between the background knowledge and the experimental results.

At a higher level, we have managed to verify that it is possible to use this form of teaching using a teleconferencing system to engage the two geographically remote groups of the students and have them work as a team (as confirmed by the post-session feedback from the students). One problem observed during the session was that the lecturer appeared to focus more on the remote end of the video link, seemingly overlooking the local students. There are several factors in play here, one being the size of the groups (4 students local, 6 remote) with the teacher spending more time in visual contact with the distant group due to the effort to maintain eye contact with everybody.

Another aspect are the technical limitations of the video system, such as the need to stand in precise spot in order to be visible for the remote end and to be able to maintain eye contact which didn't correspond with the most natural location for teaching the local students due to the location of the screens and camera. The camera was higher than the the local students, resulting in the impression of the teacher “looking through” or “looking over” them. Finally there were persistent problems with audio, requiring more frequent communication back & forth with the remote group to make sure they are able to understand what is being said.

6. Conclusion

We have described how we conducted a workshop on the topic of “Immersion, presence and tele-presence” and how the use of a videoconferencing system and limited VR equipment could let the students learn these concepts by experiencing the feelings and discovering the inherent problems by themselves.

There was a massive activity during the workshop and the students were positively engaged in all exercises. Getting 'hands on' experience obviously gave the students a much clearer understanding of the abstract concepts. The careful design of the workshop optimized the pedagogical efficiency of the experience, and compensated for the expensive access of students to the equipment.

It is possible to teach students the concepts of immersion and presence and to give concrete experience which supports the students understanding of the subject while avoiding any programming and any involvement of 3D graphics, thus providing an even more focused and powerful learning impact.

Based on our observations, we could confirm some of our hypothesis (communication and visibility problems, immersion at a remote location, etc.) and infirm others (reference system not so useful, avatar-alike immersion not very convincing). We hope this will help in the design of a better version of this workshop, maybe relying less on the HMD (too hard to follow the operator) but inventing other tasks which could support other aspects (e.g. team work).

We imagine such teaching activities could take place worldwide between collaborating universities, thus allowing them to share their resources and to promote the teaching of VR to non technical students, hopefully extending the awareness of the possibilities in this field.

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References

[1] Heeter, C., 1992. Being there: the subjective experience of presence, *Presence: Teleoperators and Virtual Environments 1(2)*, MIT Press, 262–271.

[2] Slater, M., and Usoh, M., 1993. Representations systems, perceptual position, and presence in immersive virtual environments. *Presence: Teleoperators and Virtual Environments, 2(3)*, MIT Press, 221–233.

[3] Lombard M. and Ditton T., 1997. At the Heart of It All: The Concept of Presence. *Journal of Computer-Mediated Communication, 3(2)*, September 1997.

[4] Computing Curricula 2001, Computer Science, Final Report. *IEEE Computer Society and Association for Computing Machinery*. Retrieved from http://www.acm.org/education/curric_vols/cc2001.pdf in March 2008.

[5] Kalawsky, R. S., 1993. The Science of Virtual Reality and Virtual Environments: A Technical, Scientific and Engineering Reference on Virtual Environments, *Addison-Wesley, Wokingham*, Reading, England.

[6] Burdea, G. C., 2004. Teaching Virtual Reality: Why and How?. *Presence: Teleoperators and Virtual Environments, 13(4)*, MIT Press, 463-483.

[7] Sherman, W. and Craig, A.B., 2002. Understanding Virtual Reality: Interface, Application, and Design. *Morgan Kaufman Publishers.*

[8] Stanney, K. M. (ed.), 2002. Handbook of Virtual Environments: Design, Implementation, and Applications. *Lawrence Erlbaum Associates, Inc.*, Mahwah, New Jersey.

[9] Burdea, G.C., and Coiffet, P., 2003. Virtual Reality Technology, 2nd Edition, *Wiley-Interscience*.

[10] Kim, G. J., 2005. Designing Virtual Reality Systems: The Structured Approach. *Springer* London.

[11] Bell, D. H., 1996. Teaching virtual reality. *SIGCSE Bulletin, 28(2)*, Jun. 1996, ACM, 56-61.

[12] Stansfield, S., 2005. An introductory VR course for undergraduates incorporating foundation, experience and capstone. *SIGCSE Bulletin, 37(1)*, Feb. 2005, ACM, 197-200.

[13] Wood J. (Ed), 1998. The virtual embodied. *Routledge*, London.

[14] Riva G., Davide F. and IJsselsteijn W.A. (Eds.), 2003. Being There: Concepts, effects and measurement of user presence in synthetic environments. *Ios Press*, Amsterdam, The Netherlands.

[15] Slater, M. 2004. How Colorful Was Your Day? Why Questionnaires Cannot Assess Presence in Virtual Environments. *Presence: Teleoperators and Virtual Environments*, 13(4), 484-493.

[16] Reyes-Lecuona, A. and Diaz-Estrella, A., 2006. New interaction paradigms in virtual environments. *Electrotechnical Conference, MELECON 2006, IEEE Mediterranean.* 16-19 May 2006, 449-452.

[17] Kolomos A., Fink F.K. and Krogh L.(Eds), 2004. The Aalborg PBL Model: Progress, Diversity and Challenges. *Aalborg University Press*, Aalborg, Denmark.

[18] Biggs J.B., 2003. Teaching for Quality Learning at University, 2nd ed., *Open University Press*, United Kingdom.

[19] Lepecq J.C., Pergandi J.M., Coyle T., Bringoux L., and Mestre D., 2007. Walking through a virtual aperture as an assessment of presence. *Proc 4th International Conference on Enactive Interfaces*, Nov. 19-24, Grenoble, FR, 149-152.